

<b>TEST PROCEDURE</b>		<b>TP 752C</b>
<b>Title</b> Heavy-Duty Diesel Engine Startup		<b>Page Number</b> 1 of 18
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<b>Responsible Organization</b> Testing Services Division - Heavy-Duty Engine Testing		<b>Computer Program</b> NA
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#### **Implementation Approval**

Original Test Procedure Authorized by EPCN #125 on 07-26-93

#### **Revision Description**

11-20-95 The purpose of this change is to revise the procedure as described in EPCN #177.

**Note:** Specific brand names in EPA/EOD procedures are for reference only and are not an endorsement of those products.

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**1. Purpose**

The purpose of this procedure is to document the process used for initial engine startup and to document the chain of custody for the test engine.

**2. Test Article Description**

Diesel engines submitted for testing to the Environmental Protection Agency (EPA) Testing Services Division (TSD) Heavy-Duty Engine Testing (HDET). This procedure especially applies to engines defined as heavy-duty engines in the Code of Federal Regulations.

**3. References**

- 3.1 "Cellmate II Operations Manual"
- 3.2 Environmental Protection Agency (EPA) current safety policies

**4. Required Equipment**

- 4.1 Form 751-01, "HDET - Engine and Test Specification," (see TP 751)

**Note:** Form 751-01 must be completed prior to starting Section 7 of this procedure

- 4.2 Form 751-02, "HDET - Diesel Engine Setup," (see TP 751)
- 4.3 Form 752-01, "HDET - Diesel Engine Prestartup Inspection," (Attachment A)
- 4.4 Form 752-02, "HDET - Diesel Engine Startup," (Attachment B)
- 4.5 "Cellmate II Operations Manual"
- 4.6 Electric Engine Dynamometer  
Equipment used: GE, Model 42 G 408 AD
- 4.7 Throttle Amplifier  
Equipment used: Digalog Model TC
- 4.8 Constant Volume Sampler (CVS) Compressor Unit (Blower)  
Equipment used: Spencer Turbine Turbo Compressor, Model 2060 HMOD

## 4.9 Throttle Actuator

Equipment used: Foxboro-Jordan Model MC 10596

## 4.10 Dynamometer torque and speed display instruments

Equipment used: Daytronic Signal Conditioners:  
Model 9178A, Strain Gage Conditioner (1 required)  
Model 9140, Frequency-to-voltage Conditioner (1 required)  
Model 9515A, Digital Indicator (2 required)

## 4.11 Pressure Sensor

Equipment used: Omega, Series PX236

## 4.12 Test temperature monitoring system (see TP 751)

## 4.13 Engine oil pressure monitoring system (see TP 751)

## 4.14 Metallic duct tape

**5. Precautions**

- 5.1 A person must remain in the control room at the dynamometer console during engine operation, in position to activate the "EMERGENCY STOP" button if a potentially hazardous situation arises.
- 5.2 Personnel are not allowed in the test cell while the engine is in operation except to perform adjustments or tests which specifically require their presence at that time.
- 5.3 Any person entering the test cell during engine operation must wear hearing protection, safety glasses, and safety shoes. This person must stay out of line with rotating engine and drive shaft components as much as possible.
- 5.4 The engine must be checked for hydrostatic lock. Hydrostatic lock is a condition which results from an incompressible fluid collecting in a cylinder, to the extent that its volume is greater than the total volume of the combustion chamber when the piston is at top dead center. If fluid exists in the chamber at this time, the piston may not be able to complete its upward stroke, and serious damage to the engine can occur if the dynamometer is turning the engine.

Prior to starting the engine, the crankshaft is manually turned at least two revolutions in the direction of engine rotation specified on Form 751-01, to ensure that conditions of hydrostatic lock do not exist.

- 5.5 The engine oil level must be checked and, if any is added, the amount must be recorded on Form 752-01.
- 5.6 The dynamometer "SPEED" and engine "THROTTLE" controls must be rotated fully counterclockwise (to zero) before activating the control panel.
- 5.7 The engine may not be started by TSD personnel until approval is granted by the Project Officer.
- 5.8 If the exhaust is connected to the CVS unit, the "EXHAUST SELECTION VALVE" must be set to the "CELL 2" position.
- 5.9 The "ENGINE SPEED SAFETY LIMITER" is set to 100 rpm above the maximum safe engine speed.

## 6. Visual Inspection

Visual inspection of the engine and dynamometer setup is conducted before starting the engine. Instructions for specific inspections are covered in Section 7, Test Article Preparation.

## 7. Test Article Preparation

- 7.1 Verify that the engine is installed and prepared for operation as specified in TP 751.
- 7.2 On both pages of Form 752-01, record the "Engine Identification" and "Test Number."
- 7.3 On Form 752-02, record the "Engine Identification," "Test Number," "Engine Manufacturer," "Engine Serial Number," "Project Officer," and their "Phone Number." On page 2 of this form, record the "Engine Identification" and "Test Number."
- 7.4 Perform the following inspections and adjustments. As each step is completed, place a check on the appropriate corresponding line of Form 752-01.
  - 7.4.1 Before turning the console power on, position the power distribution cabinet main power switches to "CELL #2."
  - 7.4.2 Verify that the "EXHAUST SELECTION VALVE," located on the ceiling in Room 413A, is in the "CELL 2" position.  
  
If the exhaust is routed to the scrubber, enter "NA."

- 7.4.3 Verify that the dew-point and barometer valves, located in Room 413A, are in the “DYNO #2” position.
- 7.4.4 Verify that “AIR HANDLING UNIT #10” is “ON” and that the “VENTILATION CONTROL” switch is in the “TEST” position.
- If the air handler is off, notify the building service contractor.
- 7.4.5 Apply power to the motor/generator (MG) by pressing the green “START” button above the “MG SET” label. The button will illuminate when the MG set is operating. Operating the MG set ensures that the dyno armature is floating on a film of oil.
- 7.4.6 Use the spanner wrench and manually rotate the drive shaft two full revolutions, in the direction of normal rotation, to ensure that conditions of engine hydrostatic lock do not exist.
- If hydrostatic lock conditions exist during the manual rotation operation, notify the HDET Supervisor.
- 7.4.7 Check that a drip of lubricating oil is visible in the dynamometer bearing sight glasses located on either end of the dynamometer armature.
- 7.4.8 Verify that the exhaust restrictor is fully open.
- 7.4.9 If the engine exhaust is vented to the scrubber system, ensure that it is secured in place. Verify that the engine crankcase breather (road draft tube) is vented to the exhaust scrubber. Verify that a pressure sensor device (mercury manometer) is connected to the exhaust pipe between the engine and exhaust restrictor.
- See Form 751-01 for exhaust pressure sensor placement.
- 7.4.10 Verify that all exhaust pipe connections that use Marmon flanges are sealed with metallic tape.
- 7.4.11 Verify that the drive shaft and torque transducer scatter shields are in place and are secured with safety chains. Verify that the dynamometer vibration safety switches are reset.

7.4.12 Check the engine oil. On Form 752-01, put a mark the on the dip-stick drawing to indicate the oil level.

If the oil level is not sufficient, arrange to have it brought to the correct level with the required type of oil, and record the amount added.

If the oil level is over the full mark, notify the HDET Supervisor.

7.4.13 Verify the integrity of all fasteners securing the engine, test stand, and drive components.

7.4.14 Ensure that the fuel/water separator is drained, if the engine is so equipped. If no separator is present, enter "NA."

7.4.15 Verify that the coolant supply and return lines are connected to the engine.

7.4.16 Verify that the coolant valves, located near the floor, are open.

7.4.17 Verify that the engine cooling system is bled of air.

7.4.18 Attach an air line or other assembly to provide air to the engine compressor, as specified on Form 751-01. If an air line is not required, enter "NA."

7.4.19 Fill the water cooling tower until the sight gage reads approximately two-thirds full.

7.4.20 Verify that the red valve inside the water cooling tower is open.

7.4.21 If an auxiliary intercooler is installed, open the water valve to the intercooler. If there is no auxiliary intercooler, enter "NA."

7.4.22 Verify that the fuel supply and return lines are connected to the engine.

7.4.23 Verify that the fuel barrel is at least two-thirds full.

7.4.24 Verify that the emergency fuel shutoff device is installed.

7.4.25 Verify that the valves that control the flow of water to the fuel coolant system are open.

- 7.4.26 Verify that the thermocouple and solenoid leads are connected for the fuel cooling system.  
If the system is not used, enter “NA.”
- 7.4.27 If the engine exhaust is connected to the CVS unit, turn the CVS blower on.  
If the engine exhaust is connected to the scrubber, enter “NA.”
- 7.4.28 Rotate the right hand knob of the dynamometer tachometer “ENGINE SPEED SAFETY LIMITER” to 100 rpm above the maximum safe engine speed specified on Form 751-01. This tachometer is located in the upper left corner of the dynamometer console.
- 7.4.29 Set the “ENGINE ROTATION” switch to the “CW” (clockwise) or “CCW” (counterclockwise) position. The engine rotation direction is specified on Form 751-01.
- 7.4.30 Verify the “SPEED” and “THROTTLE” controls are turned fully counterclockwise to zero.
- 7.4.31 Verify that the Cellmate II is recording all the required temperatures and are connected to the correct thermocouples.  
The following must be included:  
Oil Temperature  
Fuel Temperature  
Water Temperature (coolant into the engine)  
Water Temperature (coolant out of the engine)  
Ambient Air Temperature  
Dilution Air Temperature  
Intake Air Temperature

Other measured parameters are specified on Form 751-01.



## 8. Test Procedures

The following steps may be performed in conjunction with contractor personnel.

In no case should contractor personnel request actions contrary to those specified on Form 752-02, although they may be required to take readings or make adjustments not specified in this procedure.

Any discrepancies must be resolved by the HDET Supervisor.

### 100 Test Cell Preparation

101 Visually inspect the test cell and engine for oil, fuel, or water leaks. Listen for compressed air leaks.

If leaks are apparent, notify the HDET Supervisor.

102 Turn the Cellmate II "AUTO/MANUAL" switch to the "MANUAL" position and turn the "CELL #1/CELL #2" switch to the "CELL #2" position.

103 Turn on the "THROTTLE CONTROLLER" by pressing the two yellow buttons located on the front panel. The two buttons will illuminate, indicating that the controller is on.

### 200 Dynamometer Control Panel Preparation

201 Turn the "POWER" switch to the "ON" position.

202 Turn the "FUEL / IGN." switch to the "ON" position.

203 Press the "RESET" button. A click should be heard, indicating solenoid operation, and the green light labeled "FUEL ON" will illuminate.

204 Apply power to the dynamometer by pushing the green DYNA "ON" button. The green button will illuminate, indicating that the dynamometer is ready for use.

205 On the dynamometer control panel, locate the yellow "CONTROL" button labeled "MANUAL" and press it three times.

**300 Engine Control Box Function**

301 If the engine is equipped with an diagnostic electronic control box, turn it on and observe that it functions properly.

If the engine is not equipped with an diagnostic electronic control box, enter “NA” on Form 752-01.

If the control box functions properly, place a check on Form 752-01.

If the box is malfunctioning, notify the HDET Supervisor.

302 Sign and date Form 752-01.

**400 Release Engine for Starting**

401 Verify that Form 752-01 has been completed.

402 Notify the personnel responsible for ensuring that the engine is ready to be started. They will verify that the engine is ready to be started and notify the HDET Supervisor. The engine may be released for initial start by following either method described in Steps 403 or 404.

403 If the engine is for Recall Testing, the contractor will notify Manufacturers Operation Division (MOD) that the engine is ready to be started.

If an MOD representative is not available on-site, HDET will fax MOD Forms 752-01 and 752-02. MOD will review Form 752-01 for completeness.

If Form 752-01 meets all acceptance criteria, the Project Officer will print their name and phone number on Form 752-02. The Project Officer will sign and date “Release Engine for Initial Start” section of Form 752-02 and release the engine to TSD. The Project Officer will enter the Engine Initial Operation Cycle “Command Speed” and “Command Torque” data on Form 752-02.

If an alternate cycle is to be performed, the Project Officer will enter the Engine Initial Operation Alternate Cycle “Command Speed,” “Command Torque,” and “Condition” data on Form 752-02.

MOD will fax Form 752-02 back to HDET.

404 The Project Officer may verbally release the engine for initial start and provide the required data to complete Form 752-02.

If they verbally release the engine, the HDET Supervisor must sign and date the "Release Engine for Initial Start" section of Form 752-02.

If an alternate cycle is to be performed, the HDET Supervisor will enter the Engine Initial Operation Alternate Cycle "Command Speed," "Command Torque," and "Condition" data on Form 752-02.

#### **500 Verify Oil Pressure**

501 Verify that the "Release Engine for Initial Start" section of Form 752-02 has been signed by either the Project Officer or the HDET Supervisor.

If no signature is present, notify the HDET Supervisor.

502 Verify that the emergency fuel shutoff system is not energized so fuel cannot flow into the engine.

503 Rotate the "SPEED" control clockwise to obtain a reading on the dynamometer console tachometer between 200 and 300 rpm.

504 Observe the oil pressure readout.

If oil pressure is not observed within 15 seconds, immediately stop the engine by turning the "SPEED" control fully counterclockwise to zero, and notify the HDET Supervisor.

If the oil pressure is at least 15 psig at 200 to 300 rpm, stop the engine rotation by turning the "SPEED" control fully counterclockwise to zero.

#### **600 Engine Operation**

601 Energize the emergency fuel shutoff system so that fuel is allowed to flow into the engine.

602 On Form 751-01, locate the "Curb Idle Speed." Use the dynamometer "SPEED" control to operate the engine at the specified rpm.

603 After approximately 15 seconds, turn the “THROTTLE” control clockwise until the engine torque displayed on the Daytronic digital readout is a positive value.

If positive torque is not observed, return the “THROTTLE” control to zero, allow the dynamometer to continue rotating the engine at idle speed for 15 more seconds, and open the throttle again. Repeat this step up to four times or until positive torque is observed.

If the engine fails to make positive torque, notify the HDET Supervisor.

604 Adjust the “SPEED” and “TORQUE” controls, on the dynamometer control console, to the “Command Speed” and “Command Torque” settings for each mode. The “Actual Speed” must be  $\pm 10$  rpm from the “Command Speed” and the “Actual Torque” must be within  $\pm 200$  lb-ft of the “Command Torque.”

605 Operate the engine at each mode for the time period specified under “Mode Time” on Form 752-02.

606 On Form 752-02, record the “Actual Speed” and “Actual Torque” readings for each mode.

607 During engine operation, observe the Cellmate II screen to ensure that temperatures do not exceed the limits specified on Form 751-01.

If temperature limits are exceeded, immediately bring the engine to idle speed for 3 minutes, then stop the engine as described in Section 700.

Notify the HDET Supervisor if the temperature limits are exceeded.

## **700 Engine Shutdown**

701 If the test sequence does not end with an idle period, allow the engine to idle at no load (closed throttle) for 3 minutes before using the dynamometer to bring the engine to zero speed.

If the test sequence ends with an idle, use the dynamometer to bring the engine to zero speed at the completion of the sequence.

702 Turn the “POWER” switch on the dyno control panel to “OFF.”

703 Turn the “FUEL / IGN.” switch to “OFF.”

704 Press the red “Stop” button for the M.G. SET.

705 Sign and date Form 752-02. Deliver the form to the HDET Supervisor. The supervisor will notify the Project Officer that the process is complete and will request that they sign the “Release Engine for Testing” section on Form 752-02.

The Project Officer may verbally release the engine to HDET for testing. If they verbally release the engine, the HDET Supervisor must sign and date the “Release Engine for Testing” section Form 752-02.

## **9. Data Input**

9.1 Form 752-01 is completed

9.2 The actual speed and torque values for the engine are recorded on Form 752-02.

9.3 The Project Officer or HDET Supervisor signed and dated the “Release Engine for Initial Start” and “Release Engine for Testing” sections of Form 752-02.

## **10. Data Analysis**

10.1 Form 752-01 is reviewed to ensure that all data have been recorded.

10.2 The data on Form 752-02 are reviewed by the Project Officer or HDET Supervisor to ensure that the engine is ready for testing.

## **11. Data Output**

11.1 Form 752-01 is completed, signed, and placed in the test packet labeled with the corresponding “Engine Identification” and “Associated Data.”

11.2 Form 752-02 is completed, signed, and placed in the test packet labeled with the corresponding “Engine Identification” and “Associated Data.”

## **12. Acceptance Criteria**

12.1 The Project Officer or HDET Supervisor has signed and dated the “Release Engine for Initial Start” section of Form 752-02.

- 12.2 The Project Officer or HDET Supervisor has recorded the initial or alternate engine operation cycles on Form 752-02.
- 12.3 The engine has been operated through the specified modes on Form 752-02.
- 12.4 The Project Officer or HDET Supervisor has signed and dated the “Release Engine for Testing” section of Form 752-02.
- 12.5 Specified engine operation temperature limits have not been exceeded.
- 12.6 Measured speed readings must be within  $\pm 10$  rpm of the “Command Speed” on Form 752-02.
- 12.7 Measured torque readings must be within  $\pm 200$  lb-ft of the “Command Torque” on Form 752-02.
- 12.8 The oil pressure must be a minimum of 15 psig at 200 to 300 rpm.

### **13. Quality Provisions**

- 13.1 All initial engine operation sequence test points have been run as specified.
- 13.2 All required data are recorded on Form 752-01.
- 13.3 All data sheets have been verified, signed, and dated by a technician.

## HDET - Diesel Engine Prestartup Inspection

Engine Identification: \_\_\_\_\_ Test Number: \_\_\_\_\_

### Test Article Preparations

- \_\_\_\_\_ Main power to Cell #2
- \_\_\_\_\_ Exhaust tunnel selection lever on Cell #2 (or NA)
- \_\_\_\_\_ Dew-point and barometer valves in Dyno #2 position
- \_\_\_\_\_ Air handler "ON" and in "TEST" position
- \_\_\_\_\_ Engage M/G set
- \_\_\_\_\_ Engine crankshaft manually rotated two revolutions
- \_\_\_\_\_ Dynamometer lubricant level OK
- \_\_\_\_\_ Restrictors fully open or \_\_\_\_\_ adjusted to the engine specification
- \_\_\_\_\_ Exhaust vented and secured
- \_\_\_\_\_ Exhaust the road draft tube is vented and secured
- \_\_\_\_\_ Exhaust pressure sensor connected (or NA)
- \_\_\_\_\_ Exhaust pipe connections sealed
- \_\_\_\_\_ Drive shaft/torque transducer shields secure
- \_\_\_\_\_ Safety switches reset
- \_\_\_\_\_ Engine oil level OK
- Place a mark on the drawing to indicate the oil level:



(Not to Scale)

If low, record amount of oil added = \_\_\_\_\_

- \_\_\_\_\_ Integrity of all mounting fasteners verified
- \_\_\_\_\_ Fuel/water separator drained (or NA)
- \_\_\_\_\_ Coolant supply and return lines connected to engine.
- \_\_\_\_\_ Coolant valves open

**HDET - Diesel Engine Prestartup Inspection****Engine Identification:** \_\_\_\_\_ **Test Number:** \_\_\_\_\_

- \_\_\_\_\_ Air bled from engine cooling system
- \_\_\_\_\_ Air line connected to compressor (or NA)
- \_\_\_\_\_ Cooling tower water level OK
- \_\_\_\_\_ Cooling tower red water valve open
- \_\_\_\_\_ Auxiliary intercooler water valve open (or NA)
- \_\_\_\_\_ Fuel lines connected
- \_\_\_\_\_ Fuel barrel at least  $\frac{2}{3}$  full
- \_\_\_\_\_ Emergency fuel shutoff installed
- \_\_\_\_\_ Fuel coolant valves open
- \_\_\_\_\_ Fuel cooling system thermocouples and solenoids connected (or NA)
- \_\_\_\_\_ CVS blower on (or NA)
- \_\_\_\_\_ "ENGINE SPEED SAFETY LIMITER" set
- \_\_\_\_\_ "ENGINE ROTATION" switch set properly
- \_\_\_\_\_ Dyno "SPEED" and "THROTTLE" controls at zero
- \_\_\_\_\_ Cellmate II recording required temperatures

**Engine Control Box Function**

- \_\_\_\_\_ Engine diagnostic electronic control box functions properly (or NA)

I have performed the steps in accordance with the requirements of Test Procedure 752.

Technician's Name: \_\_\_\_\_ Date: \_\_\_\_\_

I verify that the above inspections and adjustments have been completed.

Verified by: \_\_\_\_\_ Date: \_\_\_\_\_



## HDET - Diesel Engine Startup

**Engine Identification:** \_\_\_\_\_ **Test Number:** \_\_\_\_\_

Engine Manufacturer: \_\_\_\_\_

Engine Serial Number: \_\_\_\_\_

Project Officer: \_\_\_\_\_ Phone Number: \_\_\_\_\_

### Release Engine for Initial Start

I hereby certify that I have reviewed Form 751-02, prepared for the engine described above, and based on this document, I believe that this engine has been correctly prepared for testing in accordance with Form 751-01.

I authorize TSD personnel to perform the initial startup of this engine and to perform the Engine Initial Operation Cycle or, if required, the Engine Initial Operation Alternate Cycle.

Project Officer: \_\_\_\_\_ Date: \_\_\_\_\_

The Project Officer has verbally approved release of this engine for initial start.

HDET Supervisor: \_\_\_\_\_ Date: \_\_\_\_\_

### Engine Initial Operation Cycle

Mode Time (minutes)	Command Speed (rpm)	Actual Speed (±10 rpm)	Command Torque (lb-ft)	Actual Torque (±200 lb-ft)	Engine Speed / Load
1	idle	_____	no load	_____	idle
3	_____	_____	_____	_____	rated-speed @ 1/2 load
2	_____	_____	_____	_____	mid-speed @ full load
5	_____	_____	_____	_____	rated-speed @ 3/4 load
2	_____	_____	_____	_____	mid-speed @ full load
5	_____	_____	_____	_____	rated-speed @ full load
2	idle	_____	no load	_____	idle

## HDET - Diesel Engine Startup

**Engine Identification:** \_\_\_\_\_ **Test Number:** \_\_\_\_\_

### Engine Initial Operation Alternate Cycle

If an alternate cycle is to be performed, indicate the modes below:

Mode Time (minutes)	Command Speed (rpm)	Actual Speed ( $\pm 10$ rpm)	Command Torque (lb-ft)	Actual Torque ( $\pm 200$ lb-ft)	Engine Speed / Load
_____	idle	_____	no load	_____	idle
_____	S	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	A	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	M	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	idle	_____	no load	_____	idle

I have performed the (Alternate) Engine Initial Operation Cycle in accordance with the requirements of Test Procedure 752.

Technician's Name: \_\_\_\_\_ Date: \_\_\_\_\_

I have reviewed this form and verify that it is complete.

Verified by: \_\_\_\_\_ Date: \_\_\_\_\_

### Release Engine for Testing

I hereby certify that I have reviewed Form 752-02, prepared for the engine described above, and based on this document, I believe that this engine has been correctly started and that the initial engine test sequence has been correctly performed in accordance with TP 752.

I hereby release the engine to HDET for testing under the test plan set forth on Form 751-01.

Project Officer: \_\_\_\_\_ Date: \_\_\_\_\_

The Project Officer has verbally approved release of this engine for testing

HDET Supervisor: \_\_\_\_\_ Date: \_\_\_\_\_